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The Food Dye Is Cast

What They Are, Why We Need Them, and if They Are Killing Us

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Illustrated by Ellie Le Tu

What do sea snails, mercury, lead, and coal have in common? People have used each of these compounds to color food. Mediterranean civilizations extracted Tyrian, a purple dye, from sea snail mucus, through a process so expensive that merely owning purple robes and sugars signified royal extravagance. Seventeenth-century merchants used mercury sulfide to hide impurities in red spice stocks. American dairy purveyors throughout the 1800s disguised watered-down milk with the corrosive yellow-white additive lead chromate. Clever chemists turned the carbon-rich sludge of coal coking plants into the precursors of many familiar chemicals, from topical medicines and acetaminophen to artificial dyes for food and cloth.

These bizarre experiments demonstrate the importance we place on the color of foods. Research suggests that our brains ignore even the most delectable of flavors when our food's color is amiss. Sight contributes far more to the eating experience than we realize. Food manufacturers rely on dozens of chemicals to enhance their products accordingly.

Most food dyes today come from nature. Plants are naturally equipped with the ability to produce an array of colors. One prominent class of natural dyes is the carotenoids, a family of molecules that produce the yellow of saffron and annatto extract, the orange of carrots and sweet potatoes, and the red-orange of tomatoes and paprika. Another molecular family, the anthocyanins, bestows a wide range of reds, purples, and blues on our foods. Dried beets and turmeric provide alternative red and yellow dyes, and green drinks may contain chlorophyll from spinach or alfalfa. Beyond plants, food manufacturers have incorporated brown compounds from caramelized sugars into sodas and candies and have even used dried-up innards of parasitic cactus insects to create the red compound carmine.

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While these dyes are called "natural," they may not come from natural sources. Food manufacturers make "natural-identical" colorants by synthesizing these naturally-occurring chemicals in a laboratory instead of extracting them from nature. However they are procured, the end result is the same.

Naturally-occurring dyes have common, healthy effects in their chemistry. Their brilliant colors reflect molecular structures in which electrons flow across the molecule, contrasting their usual confinement in individual atoms. Many such unconstrained structures defuse reactive free radicals in the body — the hallmark of effective antioxidants. Carotenoids, anthocyanins, beetroot extract, and turmeric seem to survive digestion and provide potent antioxidant activity once they enter the body.

But not all natural dyes are created equal. Some carotenoids, including the ubiquitous beta-carotene, help the body sustain adequate Vitamin A levels; Vitamin B2, creates a clear-yellow tint on many foods and vitamin capsules. Conversely, carmine appears to have dangerous allergenic qualities for people with food sensitivities. The heating process that caramelizes sugars releases byproducts that may mutate DNA and accelerate cancer development when consumed in large amounts. Contaminants from the synthesis of natural-identical colorants may pose additional cancer risks, though the United States and other well-regulated markets minimize this danger. Finally, due to the prevailing assumption that natural dyes are harmless, scientists have little data to confirm their safety. All told, natural dyes seem somewhere between harmless and healthy when consumed in moderation.

Natural dyes are far from perfect. They cost a lot of money, impart color only in large amounts, fade with time or environmental changes like sunlight exposure, and carry intrinsic flavors that may clash with dyed foods. Synthetic dyes obviate these issues for food manufacturers, though they welcome a host of their own. These synthetic dyes, with formulaic names like "Red #40," largely originate from the fossil fuel industry — chemists synthesize them from the carbon-rich byproducts of petroleum and coal processing. This in turn continues our reliance on the fossil fuel industry.

Synthetic dyes appear less healthy than their natural counterparts. Many studies associate synthetic dye ingestion with an increased incidence of attention deficit hyperactivity disorder (ADHD) in children. Many synthetic dyes may be more potent allergens than their natural counterparts, with risks again appearing strongest for hypersensitive individuals. Contaminants from dye synthesis and byproducts of dye digestion may be carcinogenic at high doses. When consumed in amounts greater than afforded by a typical diet, synthetic yellow dyes occupy human estrogen receptors, potentially disrupting proper hormone function. Additionally, many synthetic dyes can bind to blood proteins essential for drug activity, thus interacting with medications in unknown ways. These risks may be most pronounced for children, who consume larger-than-average proportions of colorful foods.

Why would government officials permit synthetic dyes' use in food? Dyes are usually most dangerous upon entering the bloodstream, and many synthetic dyes do so only poorly. When regulators determine food dyes' acceptable daily intake (ADI) limits, they find the lowest concentration of the dye from available animal studies that causes harm and divide it by an arbitrary "safety factor" of 100 or more to obtain the ADI. Natural dyes, particularly those with decades of safe food use, receive weaker regulations.

Our affinity for good-looking food has produced a stunning display of human resourcefulness. From carrots to coal to cactus pests, food manufacturers have extracted dyes from all ends of the earth. Today, modern science has embedded these chemicals deep within our diets, particularly in processed foods. Consumers can stay safe by understanding where these dyes come from, why manufacturers use them, and how to consume dyed foods in moderation.